- 1 -

IMAGE FORMING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a technique for correcting the inclination of each individual color image in an electrophotographic color image forming
5   apparatus having a plurality of photosensitive bodies.

In an electrophotographic conventional image forming apparatus, an electrophotographic photosensitive body, serving as an image-carrying member, is charged by a static charger, the charged
10 electrophotographic photosensitive body is irradiated with light in accordance with image information to form a latent image, which is then developed by a developing device, and the developed toner image is transferred to a paper sheet or the like to form the intended image.

15 On the other hand, as color imaging techniques have become available, there has been proposed a color image forming apparatus having a plurality of image forming stations arranged in tandem, each of which performs the above-cited image forming
20 process to form a cyan image, a magenta image, a yellow image and, preferably, a black image on the respective image-carrying members, and these individual color images are transferred in their respective transfer positions to a paper sheet to form a full color image.
25 Such a color image forming apparatus of the tandem

arrangement is advantageous for high-speed operation because it has an image forming section for each individual color.

However, this apparatus involves a problem of
5 difficulty in achieving satisfactory positional registration of the individual images formed by different image forming sections. There arise deviations in the angle of the rotational axis of the electrophotographic photosensitive body drum in each
10 image forming station and in that of the fitting of the scanning optical system, leading to positional misregistrations in oblique directions (hereinafter to be collectively referred to as skews), because positional differences among the formed images of four
15 individual colors transferred to a paper sheet or the like eventually emerge as positional misregistrations or variances in tint. FIGS. 6A and 6B show skewed images, FIG. 6A showing an image skewed upward, and FIG. 6B one skewed downward.

20 FIG. 7 illustrates a configuration of tone pattern correction according to the prior art.

First, skew compensating means 23 carries out skew compensation, on the basis of a preset quantity of deviation due to skewing, in accordance with shift
25 points given from shift point setting means 24 which sets the shift points of data and a shifting direction from direction setting means 26 which indicates the direction in which the skew has arisen. The procedure

of skew compensation will be described below.

FIGS. 8A and 8B are block diagrams of the
skew compensating means. It takes out an image from
data accumulating means 35 according to the shift
5 points and shift direction, both referred to above, and
data correcting means 36 shifts at each shift point in
the correcting direction line by line to output an
image having no apparent inclination. FIGS. 9A and 9B
show skew-compensated images, FIG. 9A showing the
10 result of skew compensation of the image inclined
upward to the right, and FIG. 9B, that of skew
compensation of the image inclined downward to the
right.

However, shifting of the image line by line
15 in the skew compensation procedure invites a new
problem of tone disruption. To cope with this problem,
tone processing means 34 carries out tone pattern
correction by shifting a tone pattern stored in a tone
pattern table according to the shift points and
20 shifting direction, both referred to above. This tone
pattern correction will be described below.

FIG. 10 illustrates the configuration of tone
processing means according to the prior art. Pattern
data acquiring means 37 successively takes out pattern
25 data from the tone pattern table 33 in accordance with
a table address initial value from table address
initial value setting means 28. Binarizing means 32
compares multi-value data and the tone pattern and, if

the multi-value data are found greater than the tone

pattern, outputs print dots or, if not, outputs binary

data as non-print dots. Hereupon, a point counter 30

counts up every time an image is binarized and, when

5 the count becomes identical with a preset shift point

offset from shift point offset setting means 29, the

counter is reset. The pattern data acquiring means 37

shifts the tone pattern table by one column at a time

in a direction reverse to the aforementioned shifting

10 direction, and takes out pattern data. After that, the

point counter 30 counts up every time an image is

binarized, and resets itself when the count becomes

identical with the shift point offset; the pattern data

acquiring means 37 shifts the tone pattern table by one

15 column at a time in the direction reverse to the

aforementioned shifting direction, and takes out

pattern data, resulting in improvement of the tone

disruption.

Hereupon, the table address initial value and

20 the shift point offset value in a case where the

correcting direction of the tone pattern is upward or

downward will be described with reference to FIG. 11.

The tone pattern is an image pattern consisting of

tile-like segments pasted all over a paper sheet with

25 reference to the origin. Since the print starting

position of the image itself is also determined with

reference to the origin, the position of the tone

pattern in the print starting position is determined on

a relative basis. This position of the tone pattern is supposed to be the table address initial value. Since the shift point, too, references the origin, the print starting position and the number of picture elements

5 until the next shift point are determined. This number of picture elements is supposed to be the shift point offset value.

FIG. 12 illustrates the image after the tone pattern correction.

10 However, in the conventional configuration described above, even if an image forming apparatus which rotates binary data corrects the tone pattern by tone processing, if the image is rotated after that processing and the rotated image undergoes skew

15 compensation, the direction of tone pattern correction will be distorted with respect to the direction of skew compensation with the result that the disruption in tone pattern cannot be remedied.

SUMMARY OF THE INVENTION

20 In order to solve the above-mentioned problems, the present invention provides a configuration comprising tone processing means for converting multi-value input data into binary areal tones; a tone pattern table for storing tone patterns

25 to be used by the tone processing means; rotating means for rotating the output of the tone processing means; skew compensating means for compensating for any skew

caused by an image forming apparatus upon the output of
the rotating means; shift point setting means for
setting a skew compensating position; shifting
direction setting means for setting a shifting
5 direction according to a skew direction; and rotating
direction setting means for setting a rotating
direction, wherein the tone pattern can be corrected
even if the binary data are rotated. This
configuration enables images of high print quality to
10 be obtained by performing appropriate tone pattern
correction in advance against the disruption of
gradation resulting from the compensation for skews.

BRIEF DESCRIPTION OF THE DRAWINGS
          FIG. 1 shows an arrangement of a color image
15 forming apparatus, which is a first embodiment of the
present invention;
          FIG. 2 shows an arrangement of the tone
pattern correction against rotation in the first
embodiment of the present invention;
20   FIG. 3 shows an arrangement of tone
processing means in the first embodiment of the present
invention;
          FIG. 4 shows an arrangement of a tone pattern
table;
25   FIG. 5 shows a shifting operation of a
shiftable tone pattern table in a second embodiment of
the present invention;

- 7 -

FIG. 6 shows skewed images;

FIG. 7 shows an arrangement of the tone
pattern correction according to the prior art;

FIG. 8 shows a block diagram of skew

5 compensating means;

FIG. 9 shows skew-compensated images;

FIG. 10 shows an arrangement of tone
processing means according to the prior art;

FIG. 11 shows a table address initial value

10 and a shift point offset value in a case where the
correcting direction of the tone pattern is upward or
downward; and

FIG. 12 shows an image after tone pattern
correction.

15 PREFERRED EMBODIMENTS OF THE INVENTION

(First Embodiment)

A first embodiment of the present invention
will be described below with reference to FIGS. 1 to 4.
FIG. 1 shows an arrangement of a color image forming

20 apparatus, which is a first embodiment of the present
invention.

First of all, the process of obtaining a
color image will be described with reference to FIG. 1.

Referring to FIG. 1, in a color image forming

25 apparatus, there are arranged four image forming
stations 1a, 1b, 1c and 1d, and the image forming
stations 1a, 1b, 1c and 1d respectively have

electrophotographic photosensitive drums 2a, 2b, 2c and
2d as image carrying members, around which there are
respectively arranged dedicated charging means 3a, 3b,
3c and 3d, developing means 4a, 4b, 4c and 4d, cleaning
5   means 5a, 5b, 5c and 5d, exposing means 6a, 6b, 6c and
6d of a scanning optical system for irradiating the
respective electrophotographic photosensitive drums
with light corresponding to image information, and
transferers 8a, 8b, 8c and 8d in transferring means 7.

10   The image forming stations 1a, 1b, 1c and 1d
here are where yellow, magenta, cyan and black images
are formed, and each light 9a, 9b, 9c and 9d
corresponding to the yellow, magenta, cyan and black
images are outputted from the exposing means 6a, 6b, 6c
15   and 6d, respectively. In a mode of passing the image
forming stations 1a, 1b, 1c and 1d, an intermediate
transfer belt 12 of the endless type, supported by
rollers 10 and 11, is arranged underneath the
electrophotographic photosensitive drum 2a, 2b, 2c and
20   2d, and moves in a direction of arrow A. The
operations of these elements are controlled by control
means.

Paper sheets 16 stacked in a paper cassette
15 are fed by a feed roller 17, and discharged into a
25   paper tray (not shown) via a paper sheet transfer
roller 18 and fixing means 19.

In the above-mentioned arrangement, after a
latent image of the black color component of the image

information is first formed on the electrophotographic photosensitive drum 2d by such known electrophotographic processing means as the charging means 3d and the exposing means 6d of the image forming station 1d, it is made visible as a black toner image out of a developer containing a black toner by the developing means 4d, and the black toner image is transferred by the transferer 8d onto the intermediate transfer belt 12.

On the other hand, while the black toner image is being transferred to the intermediate transfer belt 12, the image forming station 1c forms a latent image of the cyan color component, and the developing means 4c provides a cyan toner image out of a cyan toner. The cyan toner image is transferred to the transferer 8c and superposed over the black toner image earlier transferred onto the intermediate transfer belt 12.

Hereafter, a magenta toner image and a yellow toner image are formed by similar methods. When the superposition of the toner images of the four colors on the intermediate transfer belt 12 is completed, the toner images of the four colors are collectively transferred by the paper sheet transfer roller 18 onto the paper sheet 16 fed from the paper cassette 15 by the feed roller 17, and thermally fixed by the fixing means 19 to give a full color image on the paper sheet 16. The electrophotographic photosensitive drum 2a,

2b, 2c and 2d after the completion of the transfer are cleared of the residual toner by the cleaning means 5a, 5b, 5c and 5d to be readied for the next round of image forming, and the printing operation is completed.

5   While a color image can be obtained in this manner, there arises a misregistration between each image forming station and the scanning optical system, and each color is skewed.

               FIG. 2 shows an arrangement of the tone

10 pattern correction against rotation in the fist embodiment of the present invention. The arrangement comprises tone processing means 21 for converting multi-value input data into binary areal tones; a tone pattern table 20 for storing tone patterns to be used

15 by the tone processing means; rotating means 22 for rotating the output of the tone processing means; skew compensating means 23 for compensating for any skew caused by an image forming apparatus upon the output of the rotating means; shift point setting means 24 for

20 setting a skew compensating position; shifting direction setting means 26 for setting a shifting direction according to a skew direction; and rotating direction setting means 25 for setting a rotating direction.

25   Since each means has its own skew, when each means is assembled and adjusted, the skew is measured according to its output image to assess the quantity of misregistration, and the skew is compensated for by the

skew compensating means 23.   Further description of

this skew compensation is dispensed with, because it is

no different from the prior art.   Further, as skew

compensation gives rise to a disruption in tone pattern

5   attributable to a gap of one line, the tone pattern is

corrected in advance by the tone processing means 21.

The tone pattern correction according to the

present invention will be described below.

FIG. 3 shows an arrangement of the tone

10   processing means in the first embodiment of the present

invention with particular reference to the arrangement

of the tone pattern correction.   Pattern correcting

direction determining means 27 determines in which

direction - upward, downward, leftward or rightward -

15   the tone pattern is to be shifted according to the

image rotating direction made known by the rotating

direction setting means 25 and the shifting direction

(upward or downward toward the right) made known by the

shifting direction setting means 26.   More

20   specifically, where the rotational angle is 0 degree,

if the skewing direction is upward toward the right,

the direction of tone pattern correction will be

downward or, if the skewing direction is downward

toward the right, the direction of tone pattern

25   correction will be upward.   Where the rotational angle

is 90 degrees, if the skewing direction is upward

toward the right, the direction of tone pattern

correction will be leftward or, if the skewing

direction is downward toward the right, the direction
of tone pattern correction will be rightward. Where
the rotational angle is 180 degrees, if the skewing
direction is upward toward the right, the direction of

5 tone pattern correction will be upward or, if the
skewing direction is downward toward the right, the
direction of tone pattern correction will be downward.
Or where the rotational angle is 270 degrees, if the
skewing direction is upward toward the right, the

10 direction of tone pattern correction will be rightward
or, if the skewing direction is downward toward the
right, the direction of tone pattern correction will be
leftward.

The tone pattern table 20 stores tone

15 patterns in registers each consisting of an external
memory or hardware. In this embodiment, pattern data
are supposed to be stored in a block of (rows, columns)
= (m, n) as the configuration of the tone pattern table
in FIG. 4 shows. Sets of pattern data are usually

20 stored consecutively to facilitate their taking out.
Pattern data are taken according to the table address.

Rotation-responsive pattern acquiring means
31 takes out a tone pattern from the tone pattern table
20 on the basis of the direction of tone pattern

25 correction from the pattern correcting direction
determining means 27, table address initial values
(rows, columns) = (a, b) determined from the printing
position of the image on the printing paper and preset

in the table address initial value setting means and a
shift point offset set in the shift point offset
setting means.

For a more specific description, first a case
5 in which the angle of rotation is 90 degrees, the
skewing direction is upward toward the right and the
direction of tone pattern correction is leftward will
be referred to.

As a basic operation, in the processing of
10 the first line of the image, pattern data are taken out
of the table address initial values (a, b). Every time
a set of pattern data is taken out, only the address
value in the column direction is counted up by +1, and
sets of data are taken out successively. When the
15 processing has advanced to a point where the address
value in the column direction has become equal to m,
the address value in the column direction is returned
to the beginning to make the table address (0, b).
Then, sets of pattern data are again taken out while
20 counting up the address value by +1 each time. This
processing is repeated over the whole line.

When the processing of the first line is
completed, the second line begins to be processed. The
table address then is (a, b+1), with +1 added to the
25 table address initial value in the row direction. Sets
of pattern data are taken out while varying the address
in the row direction as in the processing of the first
line. Processing of the third and subsequent lines

will be carried out in the same manner. When the line-
by-line processing has advanced to a point where the
address in the row direction has become equal to n, the
address in the row direction in the table address on
5   the next line is returned to the beginning to reduce
the address value in the row direction to 0.

For tone pattern correction, the shift point
offset value is set in the processing of the first line
as the initial value of the point counter 30. For the
10   second and subsequent lines, the point counter 30 is
counted up by +1 every time the processing advances to
the next line. When the line-by-line processing has
advanced to a point where the count of the point
counter has become equal to the shift point value, 1 is
15   subtracted from the address in the column direction of
the table address of the line, determined by the above-
described basic operation, if the address is not 0 or,
if it is 0, the address in the column direction is
converted to m. Then, the point counter 30 is cleared
20   at the same time. Similar processing is repeated for
the subsequent lines.

Next will be described a case in which the
angle of rotation is 90 degrees, the skewing direction
is downward toward the right and the direction of tone
25   pattern correction is rightward.

As a basic operation, in the processing of
the first line of the image, pattern data are taken out
of the table address initial values (a, b). Every time

a set of pattern data is taken out, only the address

value in the column direction is counted up by +1, and

sets of pattern data are taken out successively. When

the processing has advanced to a point where has become

5   equal to m, the address value in the column direction

is returned to the beginning to make the table address

(0, b). Then, sets of pattern data are again taken out

while counting up the address value by +1 each time.

This processing is repeated over the whole line.

10   When the processing of the first line is

completed, the second line begins to be processed. The

table address then is (a, b+1), with +1 added to the

table address initial value in the row direction. Sets

of pattern data are taken out while varying the address

15   in the column direction as in the processing of the

first line. Processing of the third and subsequent

lines will be carried out in the same manner. When the

line-by-line processing has advanced to a point where

the address in the row direction has become equal to n,

20   the address value in the row direction in the table

address on the next line is returned to the beginning

to reduce the address value in the row direction to 0.

For tone pattern correction, the shift point

offset value is set in the processing of the first line

25   as the initial value of the point counter 30. For the

second and subsequent lines, the point counter 30 is

counted up by +1 every time the processing advances to

the next line. When the line-by-line processing has

advanced to a point where the count of the point
counter has become equal to the shift point value, +1
is added to the address in the column direction of the
table address of the line, determined by the above-

5 described basic operation, if the address is not m or,
if it is m, the address in the column direction is
converted to 0. Then, the point counter 30 is cleared
at the same time. Similar processing is repeated for
the subsequent lines.

10   Next will be described a case in which the
angle of rotation is 180 degrees, the skewing direction
is upward toward the right and the direction of tone
pattern correction is upward.

As a basic operation, in the processing of

15 the first line of the image, pattern data are taken out
of the table address initial values (a, b). Every time
a set of pattern data is taken out, only the address
value in the column direction is counted up by +1, and
sets of data are taken out successively. When the

20 processing has advanced to a point where has become
equal to m, the address value in the column direction
is returned to the beginning to make the table address
(0, b). Then, sets of pattern data are again taken out
while counting up the address value by +1 each time.

25 This processing is repeated over the whole line.

For tone pattern correction, the shift point
offset value is set in the processing of the first line
as the initial value of the point counter 30. The

point counter 30 is counted up by +1 at every time of image processing in the line direction. When the processing has advanced to a point where the count of the point counter has become equal to the shift point

5 value, 1 is subtracted from the address in the column direction of the table address of the line if the row address, determined by the above-described basic operation, is not 0 or, if it is 0, the address in the row direction is converted to n. Then, the point

10 counter 30 is cleared at the same time. Similar processing is repeated for the subsequent lines.

When the processing of the first line is completed, the second line begins to be processed. The table address then is (a, b+1), with +1 added to the

15 table address initial value in the row direction. Sets of pattern data are taken out while varying the address in the column direction as in the processing of the first line. Processing of the third and subsequent lines will be carried out in the same manner. When the

20 line-by-line processing has advanced to a point where the address in the row direction has become equal to n, the address value in the row direction in the table address on the next line is returned to the beginning to reduce the address value in the row direction to 0.

25 Next will be described a case in which the angle of rotation is 180 degrees, the skewing direction is downward toward the right and the direction of tone pattern correction is downward.

As a basic operation, in the processing of
the first line of the image, pattern data are taken out
of the table address initial values (a, b). Every time
a set of pattern data is taken out, only the address

5   value in the column direction is counted up by +1, and
sets of data are taken out successively. When the
processing has advanced to a point where has become
equal to m, the address value in the column direction
is returned to the beginning to make the table address

10   (0, b). Then, sets of pattern data are again taken out
while counting up the address value by +1 each time.
This processing is repeated over the whole line.

For tone pattern correction, the shift point
offset value is set in the processing of the first line

15   as the initial value of the point counter 30. The
point counter 30 is counted up by +1 at every time of
image processing in the line direction. When the
processing has advanced to a point where the count of
the point counter has become equal to the shift point

20   value, +1 is added to the address in the column
direction of the table address of the line if the row
address, determined by the above-described basic
operation, is not n or, if it is n, the address in the
row direction is converted to 0. Then, the point

25   counter 30 is cleared at the same time. Similar
processing is repeated for the subsequent lines.

When the processing of the first line is
completed, the second line begins to be processed. The

table address then is (a, b+1), with +1 added to the

table address initial value in the row direction. Sets

of pattern data are taken out while varying the address

in the column direction as in the processing of the

5   first line. Processing of the third and subsequent

lines will be carried out in the same manner. When the

line-by-line processing has advanced to a point where

the address in the row direction has become equal to n,

the address value in the row direction in the table

10   address on the next line is returned to the beginning

to reduce the address value in the row direction to 0.

Since other combinations of the angle of

rotation and the skewing direction fit some case or

another of processing so far described, their

15   description is dispensed with.

Pattern data are taken out while varying the

table address successively as described above. Each

set of pattern data taken out is outputted to the

binarizing means 32, and the image is binarized through

20   comparison with its multi-value data.

The binarized image is rotated by the

rotating means 22 in a direction of rotation preset by

the rotating direction setting means 25, and outputted

to the skew compensating means 23. Description of the

25   rotation processing is dispensed with because it is

done by a known technique.

(Second Embodiment)

A second embodiment of the present invention

will now be described with reference to FIG. 5.   FIG. 5

shows a shifting operation of a shiftable tone pattern

table in the second embodiment of the present

invention.   In this second embodiment, the tone pattern

5   table 20 is supposed to be registers of a 6 × 3 size

consisting of hardware.   By varying the set point of

pattern data according to the direction of tone pattern

correction determined by the pattern correcting

direction determining means 27, the tone pattern is

10   switched.   To be more specific, the processing will be

described with reference to a case in which the

direction of tone pattern correction is leftward.   The

pattern is shifted by shifting leftward all the pattern

data set in the pattern table, as illustrated in FIG.

15   5B, when the point counter value has become equal to

the shift point value while carrying on processing in

the row direction of each line.   At this time, pattern

data on the leftmost register are stored into the

rightmost register.   Tone pattern correction in any

20   other direction is accomplished by shifting pattern

data.   In this processing to shift pattern data, the

rotation-responsive pattern acquiring means 31 does not

convert any table address by tone pattern correction.

As hitherto described, according to the

25   present invention, it is possible to improve any

disruption in tone pattern even if an image is rotated

after binarization and subjected to skew compensation,

because the disruption due to skew compensation is

adjusted in advance with consideration given to the

direction of image rotation and that of skew

compensation during the binarization. Since no

particular alternation in mechanism is required, a

5 color image forming apparatus of high print quality can

be achieved with no extra cost.